

The ATLAS

Level-1 Central Trigger

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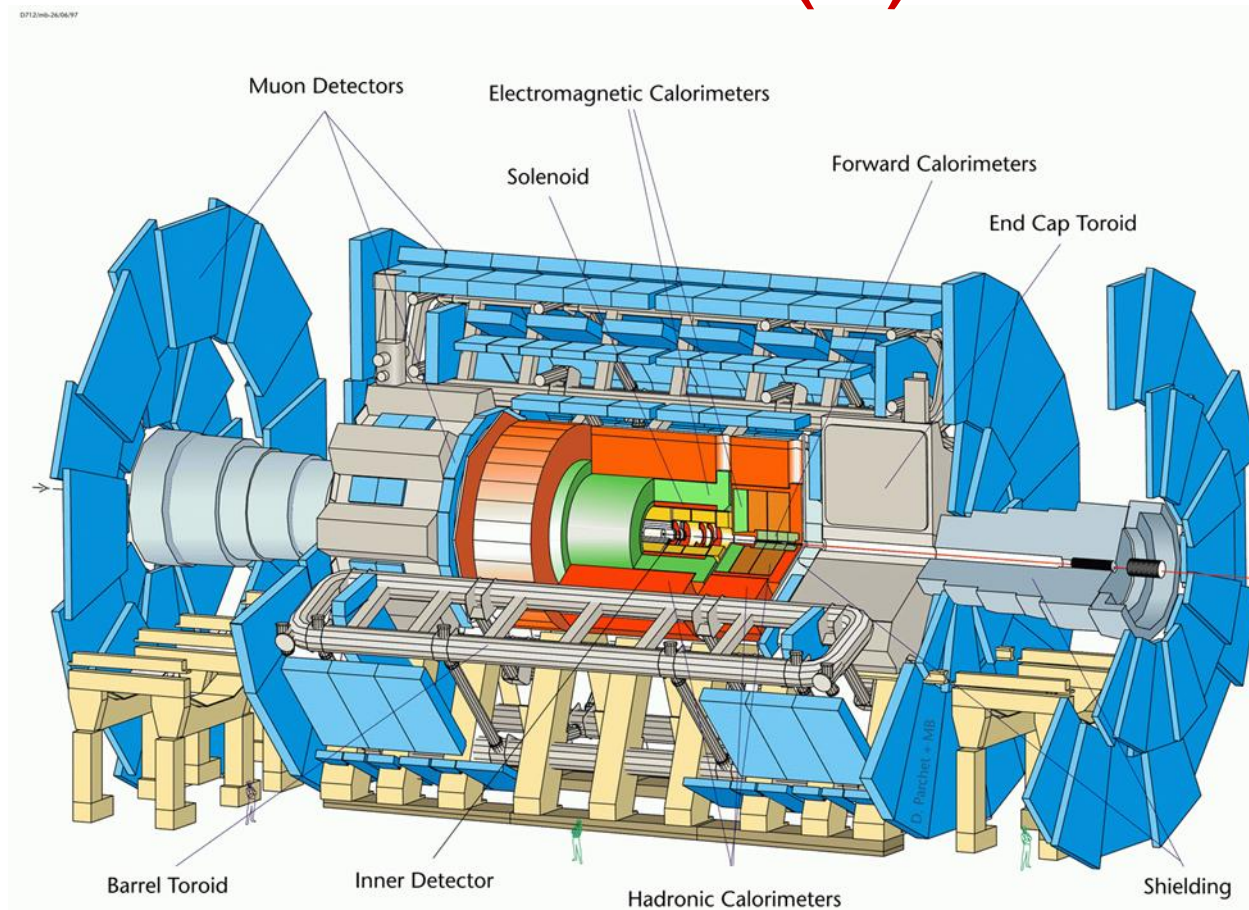
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Outline

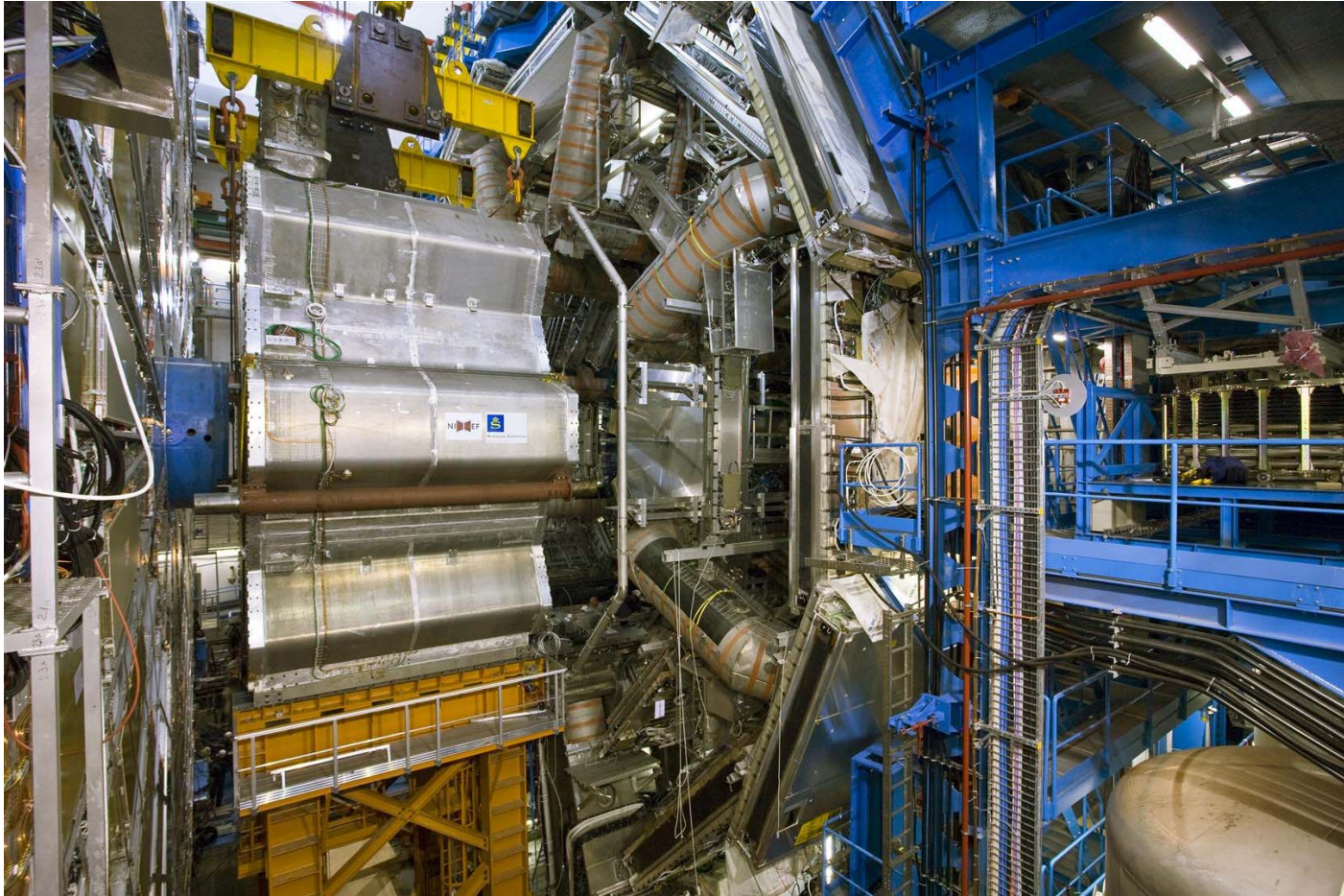
- **Introduction**
- **Level-1 Central Trigger:**
 - Muon-to-Central Trigger Processor Interface (MUCTPI)
 - Central Trigger Processor (CTP)
 - Local Trigger Processor (LTP) and Local Trigger Processor Interface Module (LTPIM)
- **Commissioning & Results:**
 - Setup
 - Software
 - Results
- **Summary**

ATLAS (1)



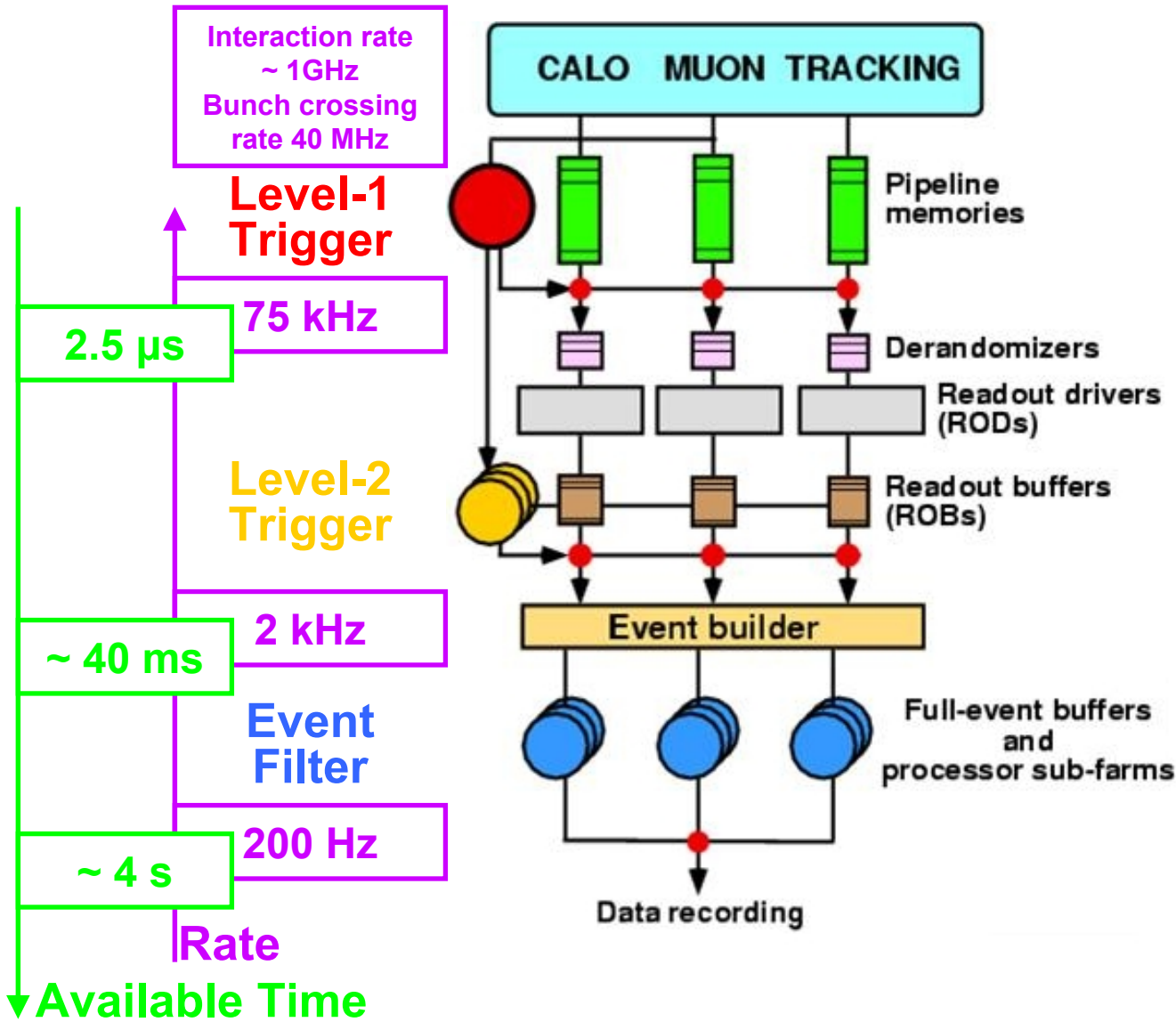
General-purpose Experiment at CERN's **Large Hadron Collider (LHC)**:
Proton-proton collisions at 14 TeV centre-of-mass energy
About 25 collisions per bunch crossing (**BC**) every 25 ns (40 MHz)
⇒ Interaction rate of 1 GHz

ATLAS (2)



Installation of the 2nd end-cap toroid magnet in July 2007

Trigger/DAQ System

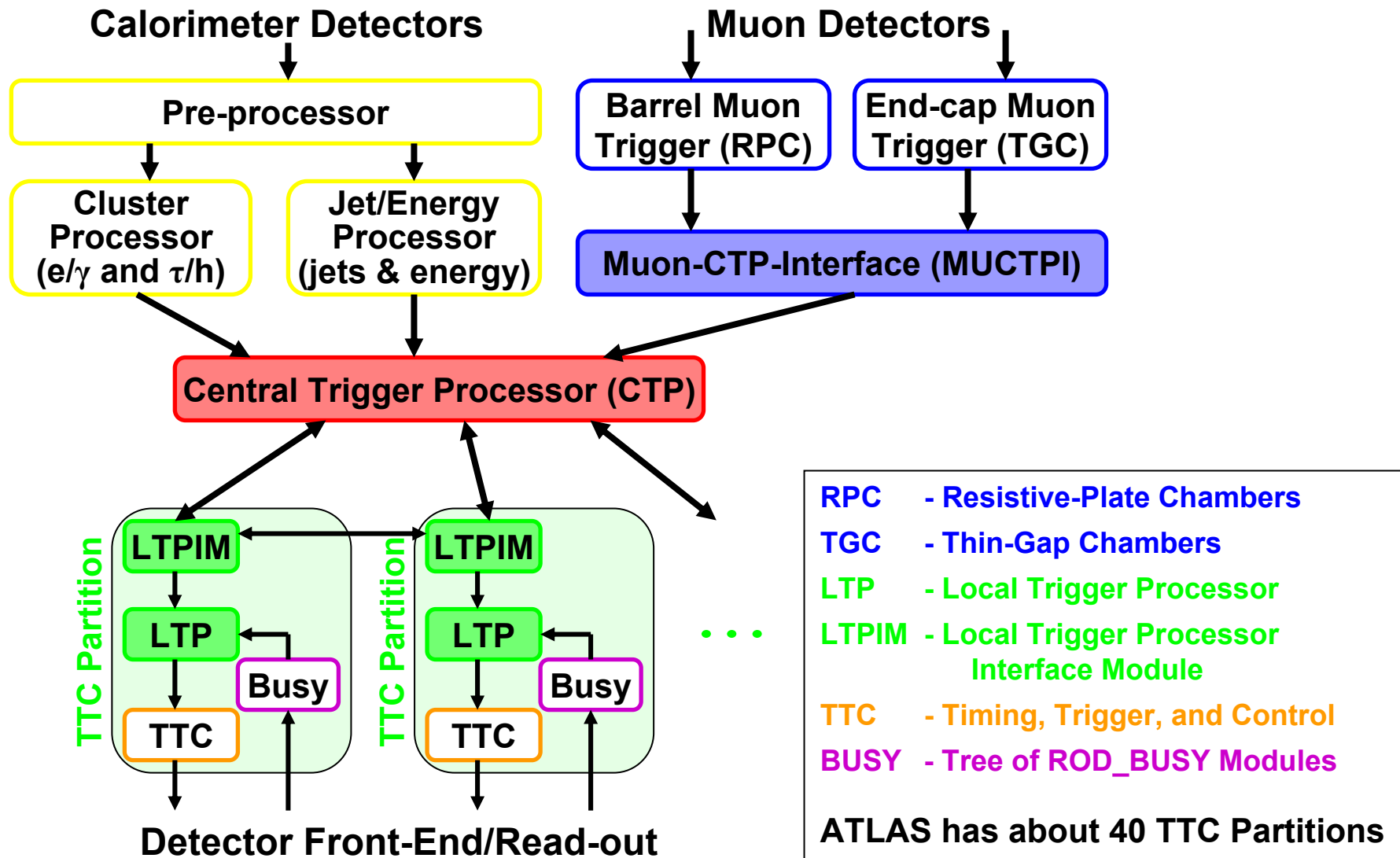


Level-1 Trigger:
Electronics + Firmware

Level-2 Trigger
+ Event Filter:

Computers + Networks + Software

Level-1 Trigger System



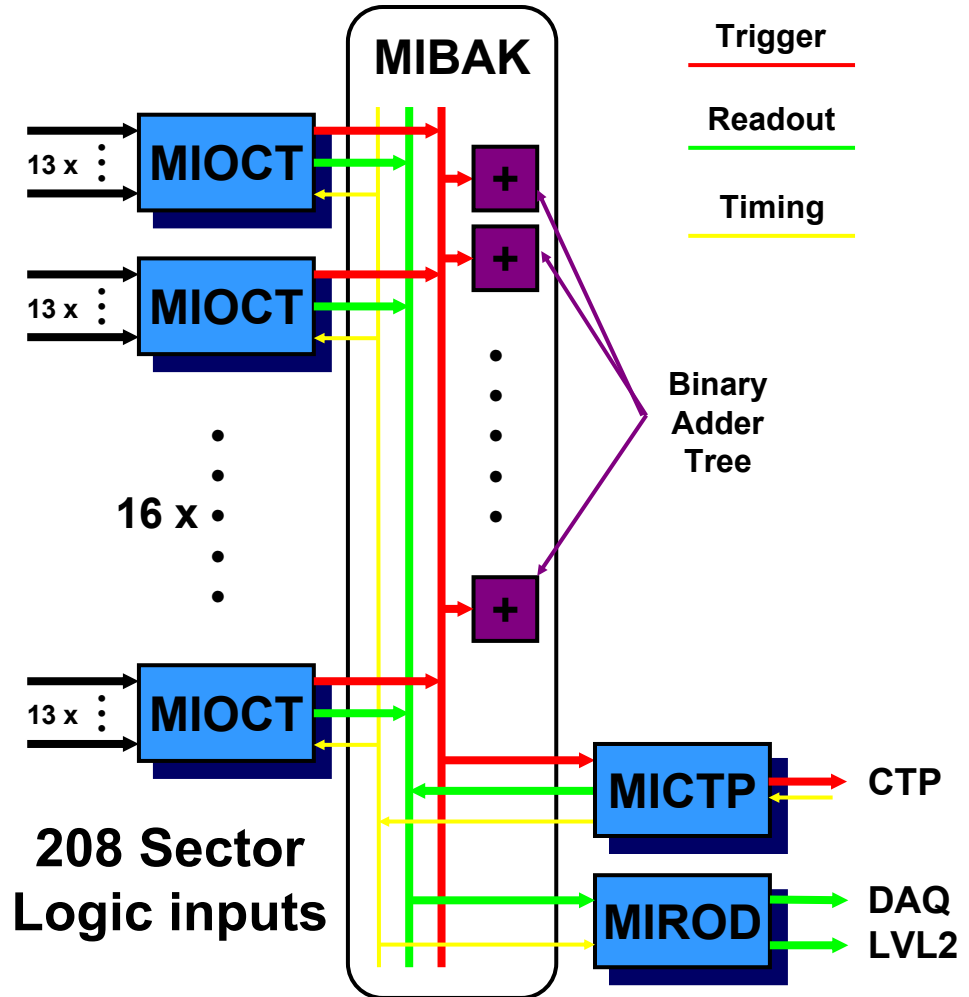
MUCTPI (1)

Functionality:

- **Receive all muon candidates from 208 trigger sectors and calculate multiplicities for 6 programmable p_T thresholds (results sent to CTP)**
- **Resolve cases where a single muon traverses more than one sector**
⇒ avoid double counting
- **Send summary information to Level-2 and to DAQ**
⇒ identify regions of interest for Level-2 trigger processing
- **Take snapshot of incoming sector data (diagnostics); accumulate rates of incoming muon candidates (monitoring)**

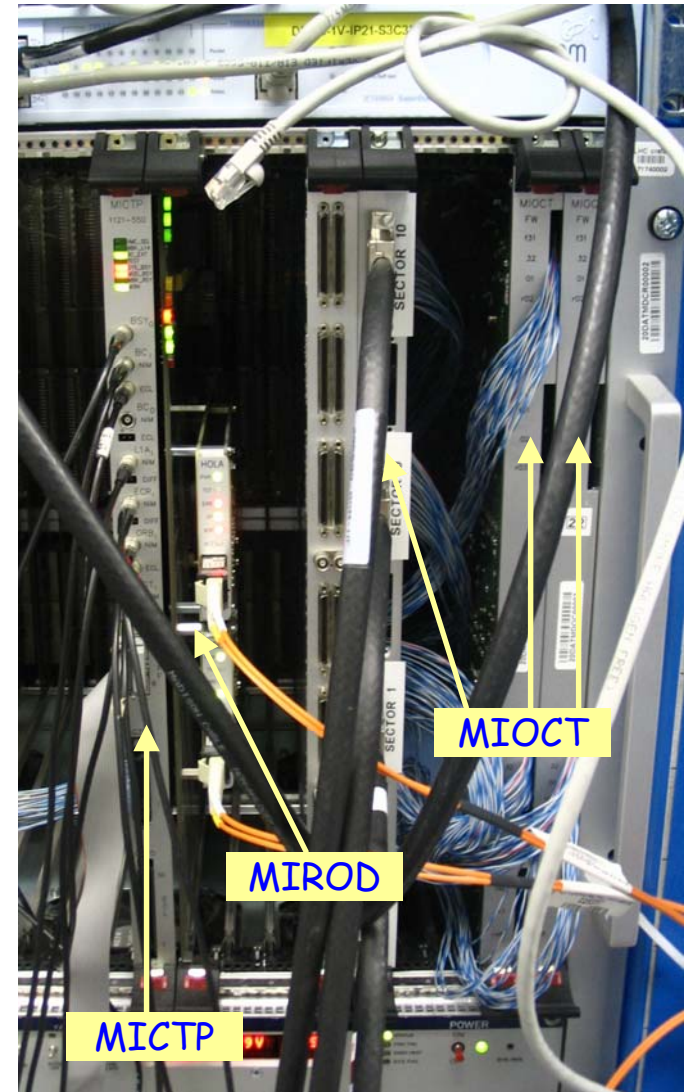
MUCTPI (2)

- **MIOCT - Octant module**
 - Receive muon candidates from muon trigger sector logic
 - Resolve overlaps
- **MIBAK - Backplane**
 - Multiplicity summing
 - Readout data transfer
 - Timing signal distribution
- **MICTP - CTP interface**
 - Multiplicity output to CTP
 - Trigger & timing signals
- **MIROD - Readout driver**
 - Send summary information to Level-2 and DAQ



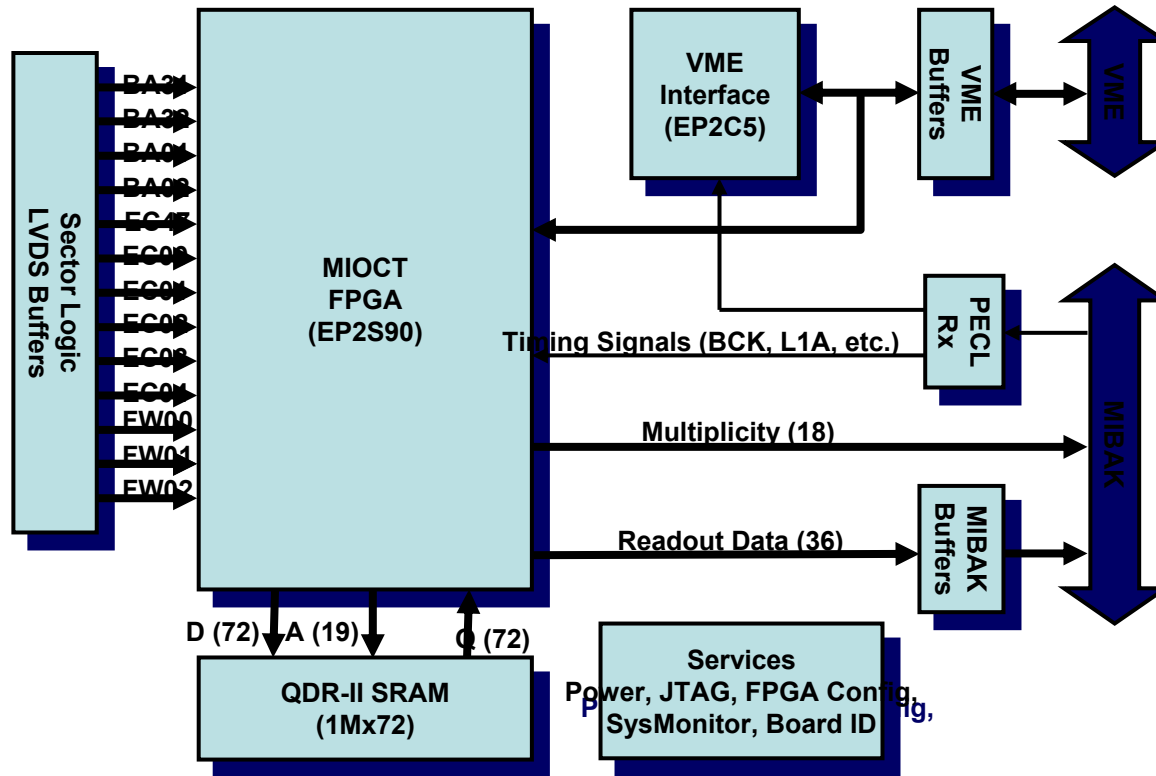
MUCTPI (3)

- **Prototype installed since 2005**
 - Provides almost full functionality
 - Missing some flexibility in overlap handling (MIOCT)
 - Being upgraded incrementally to the final system
- **MIOCT:**
 - Input module for one octant. Two old and one new MIOCTs installed
 - Currently 10 muon sectors (out of 208) are connected
- **MICTP:**
 - Timing distribution and trigger (muon multiplicities) output to CTP
- **MIROD:**
 - Output to Level-2 and DAQ using an old version of S-Link readout link (ODIN)
 - Will be replaced soon with ATLAS standard version of S-Link readout link (HOLA)
- **MIBAK:**
 - Custom active backplane for multiplicity summation and readout



MUCTPI (4)

New MIOCT Design for more flexible overlap handling:



- Prototype has been tested and is being used in the experiment
- Final production (34 modules) expected for September 2007

→ See poster by S. Haas

MUCTPI (5)

New MIROD/CTP Design:

- **Old MIROD was developed for old version of S-Link readout link (ODIN)**

Can use newer ATLAS standard version of S-Link readout link (HOLA) with adapter card

But requires more space of an additional VMEbus slot space which in the final system will be occupied by a MIOCT module

⇒ **New MIROD design with HOLA S-Link cards**

- **More recent FPGA technology**

⇒ **Migrate original design into single FPGA**

- **Same PCB as for MICTP**

⇒ **Additional spare modules for MICTP**

⇒ **Prototype is being built**

→ **See poster by S. Haas**

CTP (1)

Functionality:

- **Receive, synchronize, and align trigger inputs from calorimeter and muon trigger and others**
- **Generate Level-1 Accept (L1A) according to programmable trigger menu**
- **Additional functionality:**
 - Generate trigger-type word accompanying every L1A
 - Generate preventive dead-time in order to prevent front-end buffers from overflowing
 - Generate summary information for Level-2 and DAQ
 - Generate a precise absolute time stamp (GPS, 5 ns)
 - Generate additional timing signals (ECR)
- **Take snap shot of incoming trigger inputs (diagnostics); accumulate rates of incoming trigger inputs and generated trigger combinations (monitoring)**

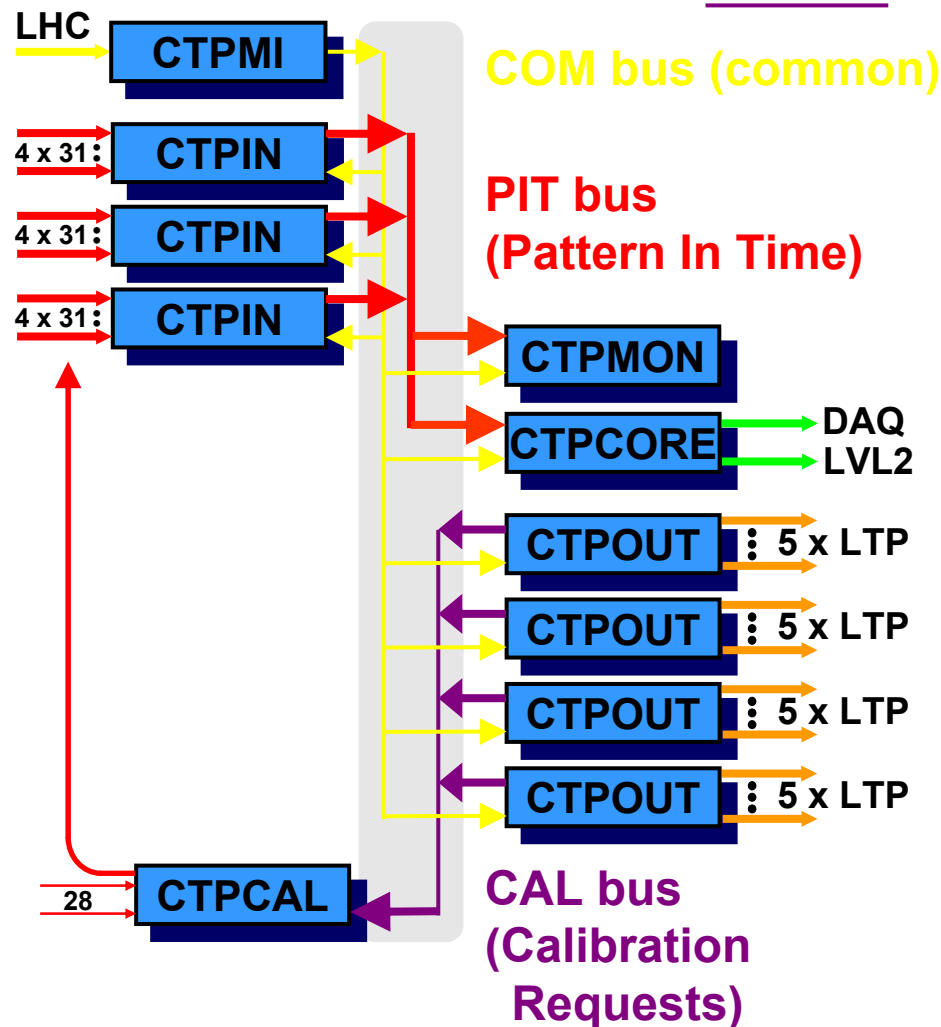
CTP (2)

Timing

Trigger

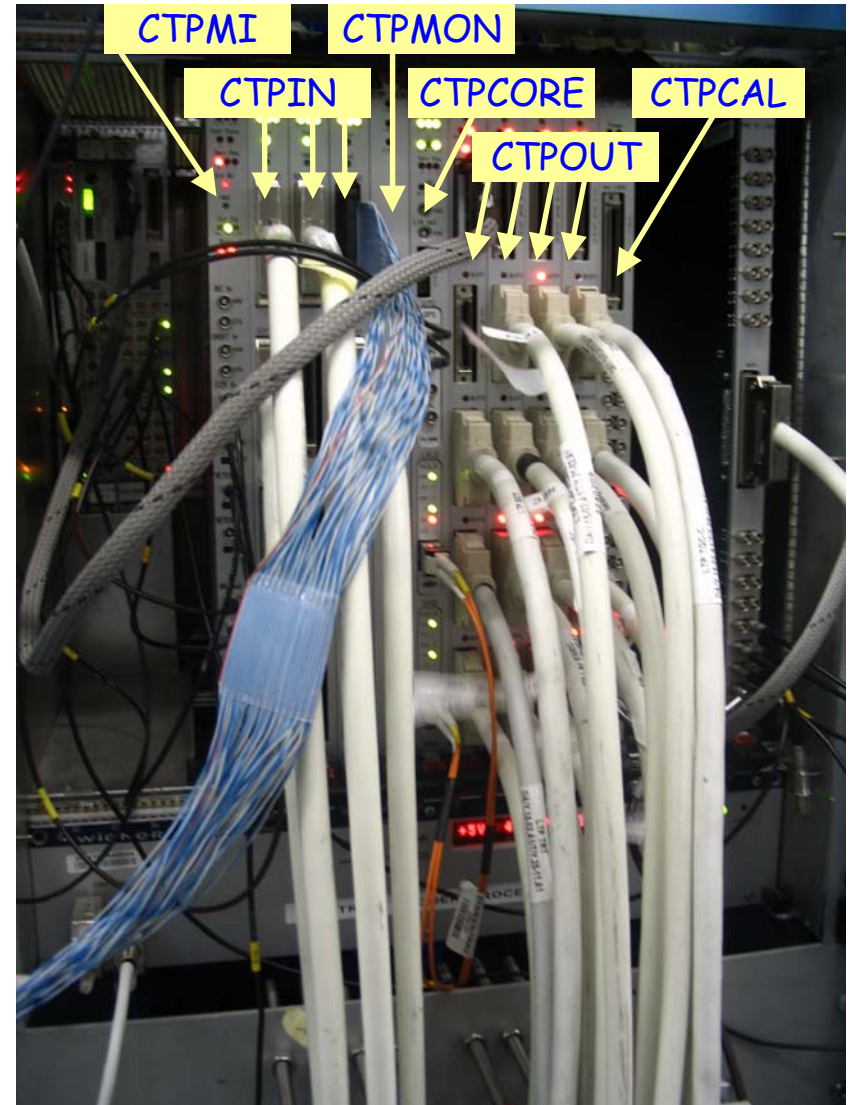
Calibration

- **CTPMI - Machine interface**
 - Receive timing signals from LHC
- **CTPIN - Input module**
 - Receive trigger input signals
 - Synchronize and align signals
- **CTPMON - Monitoring module**
 - Bunch-per-bunch monitoring
- **CTPCORE - Core module**
 - Form Level-1 Accept (L1A)
 - Send summary information to Level-2 and DAQ
- **CTPOUT - Output module**
 - Send timing signals to LTPs
 - Receive calibration requests
- **CTPCAL - Calibration module**
 - Time-multiplex calibration requests
 - Receive front-panel inputs



CTP (3)

- **Final system installed since 2006**
- **CTPMI:**
 - Clock and orbit input
- **3 × CTPINs**
 - For up to 12 trigger input cables
- **CTPMON:**
 - Monitoring of trigger input on bunch-per-bunch basis
- **CTPCORE:**
 - Trigger decision according to trigger menu
- **4 × CTPOUTs:**
 - For up to 20 outputs to sub-detectors
- **CTPCAL:**
 - Time-multiplexing of calibration requests
 - Additional individual trigger signals
- **NIM-to-LVDS fan-in module**
 - Additional individual trigger signals



CTP (4)

- **Production problems overcome:**
 - Problems with FPAG mounting on CTPIN and CTPCORE solved by remounting, all modules are working correctly
- **Last module CTPCAL produced:**
 - Time-multiplexing of calibration requests from sub-detectors, received by CTPOUT and put on CTPCAL backplane
 - 28 additional individual trigger inputs
 - CTPCAL was tested, installed, and two spares produced
- **Two more complete systems available**
 - in laboratory for spare and development (firmware modification and software development)

⇒ **CTP hardware is finished**

software development is well advanced, including issues such as monitoring and the luminosity block mechanism

LTP + LTPIM (1)

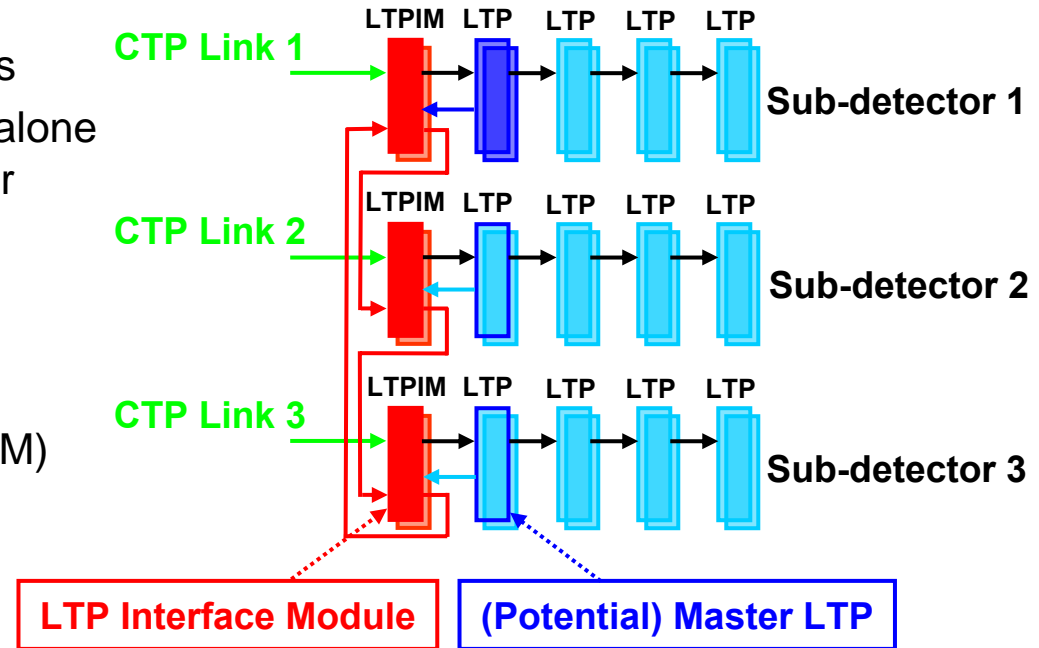
Functionality:

- **LTP:**

- Connects to CTP
- Allows to daisy-chain several LTPs
- Replaces the CTP when in stand-alone mode: use local external signals or internal pattern generator

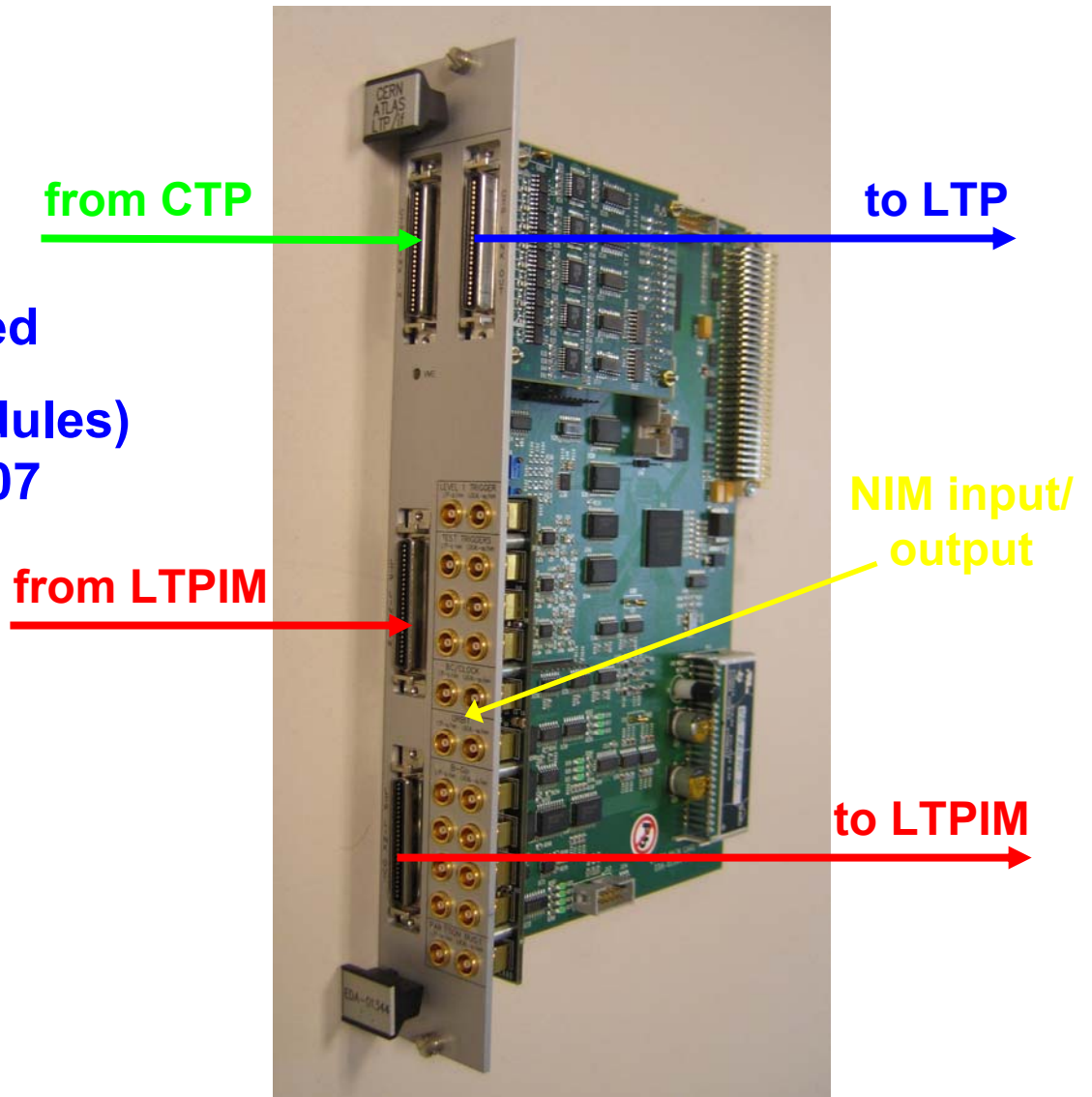
- **LTPIM:**

- "Switch module" for LTP signals
- 2 inputs (from CTP and from LTPIM)
+ local input (NIM)
- 2 outputs (to LTP and to LTPIM)
+ local output (NIM)
- Allows several combinations of sub-detectors to run and to change combinations without re-cabling, e.g. calorimeter and calorimeter trigger



LTP + LTPIM (2)

- Prototype has been tested
- Final production (34 modules) expected for October 2007



Commissioning (1)

- **Program:**

- **Routine use:**

- MUCTPI and CTP are routinely being used since more than one year to provide triggers to an increasing number of sub-detectors
 - Mainly using muon triggers (barrel and end-cap) and CTP internal triggers; basic connection tests to calorimeter trigger have been performed
 - Trigger and timing signals are provided to 14 sub-detectors

- **Several milestone weeks during 2007:**

- "M4" week from 23 AUG - 3 SEP

Commissioning (2)

Experimental Setup:

• Trigger inputs:

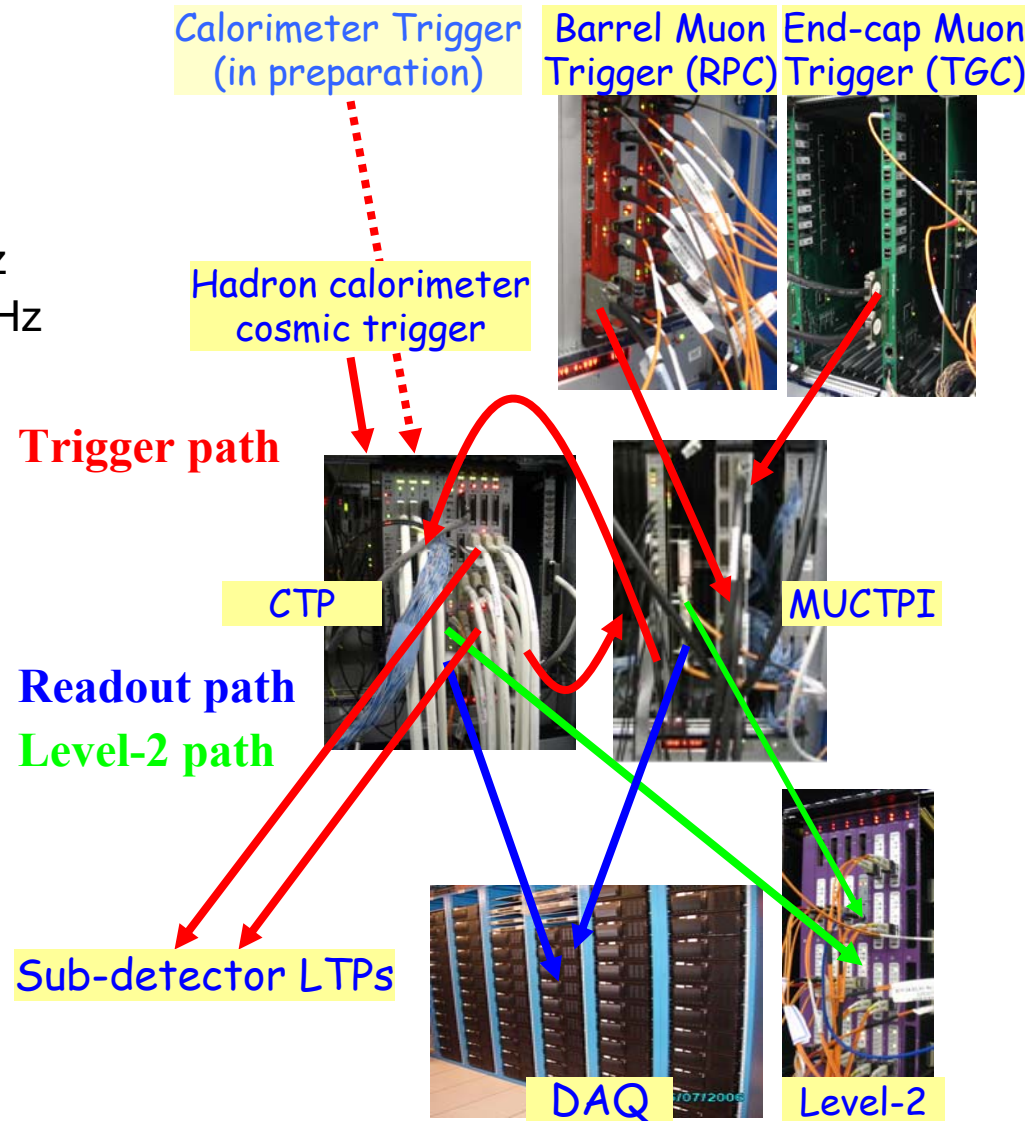
- Muon triggers to MUCTPI:
 - 4 x Barrel (RPC) sectors: 120 Hz
 - 6 x End-cap (TGC) sectors: ~ 1 Hz
- Temporary hadron calorimeter cosmic trigger (< 1 Hz)
- CTP internal triggers
- Calorimeter trigger in preparation

• Readout:

- Summary information of MUCTPI and CTP to Level-2 and DAQ

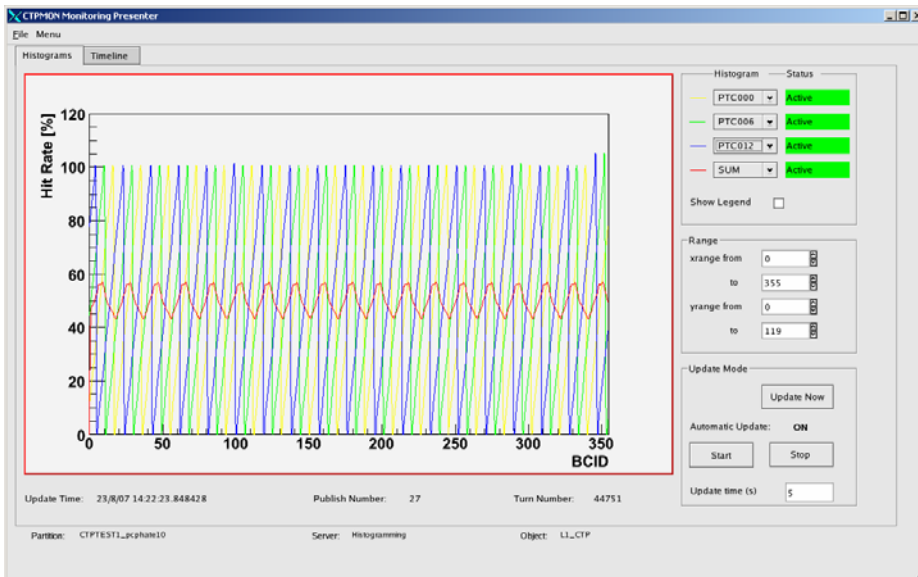
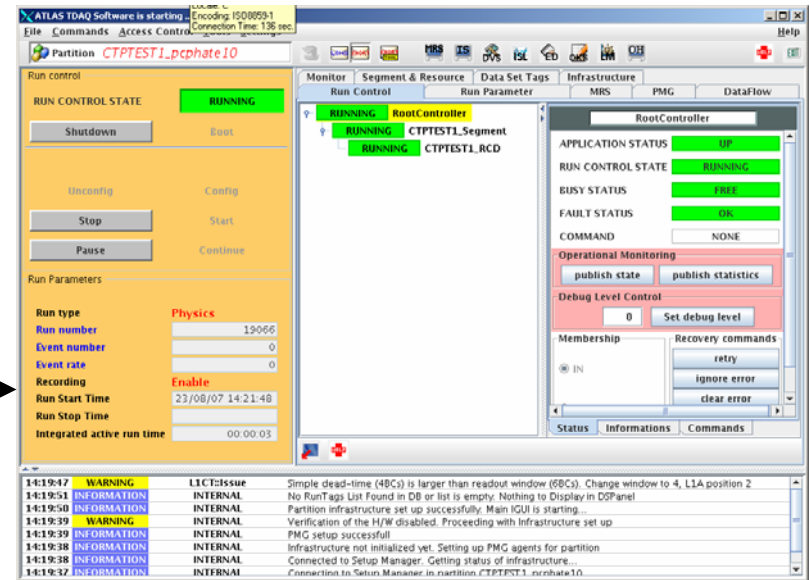
• Timing distribution:

- To almost all sub-detectors (via LTP, *LTPIM in preparation*)



Commissioning (3)

- **Run control**
- + configuration database**
 - "Plug-in" module for run control
 - Schema in configuration database
 - ATLAS graphical user interface



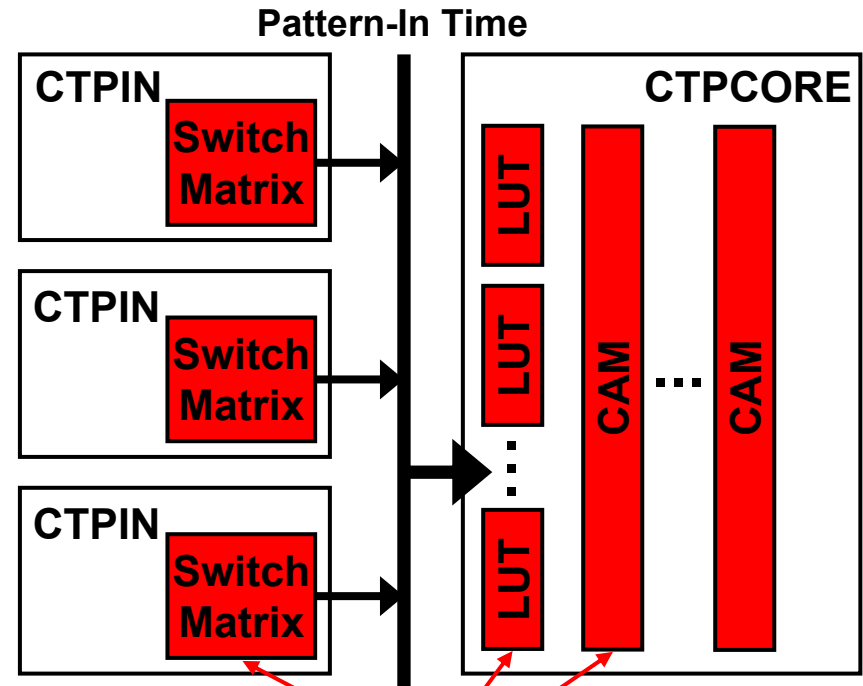
- **Monitoring**

- Input rates, bunch-per-bunch rates, combined trigger rates, BUSY status, etc.
- Bunch-per-bunch monitoring, thanks to **H. Schoorlemmer, summer student**

Commissioning (4)

Trigger Configuration

- **Trigger Database:**
Stores **event selection strategy** (Level-1, Level-2, Event Filter), **Trigger Tool** is a Graphical User Interface to browse and edit all trigger menus
- **Trigger Menu Compiler:**
Automatic translation of **high-level description** of Level-1 trigger menu to all necessary **configuration files** of the CTP:
Input: XML (high-level description)
Output: VHDL (Switch Matrix)
+ memory (LUT + CAM)

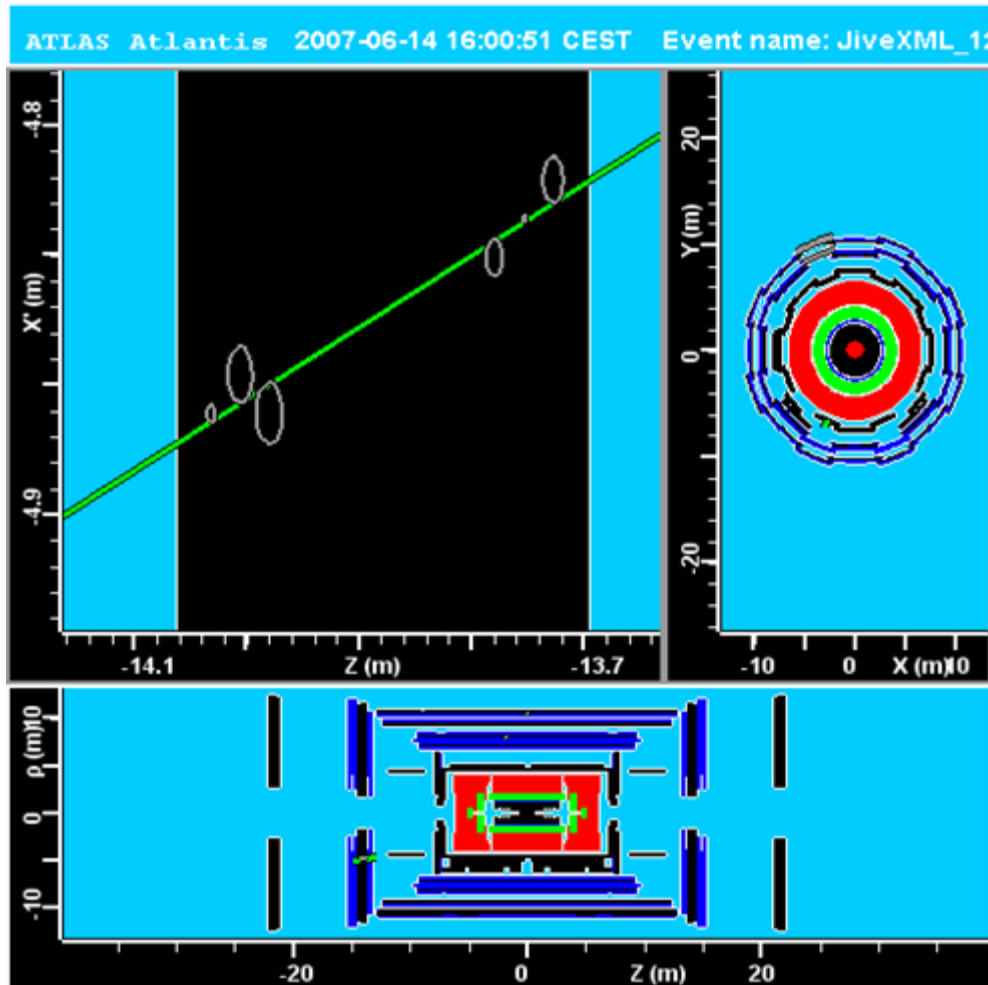


**Configuration and memory files
written by Trigger Menu Compiler**

LUT - Look-up Table

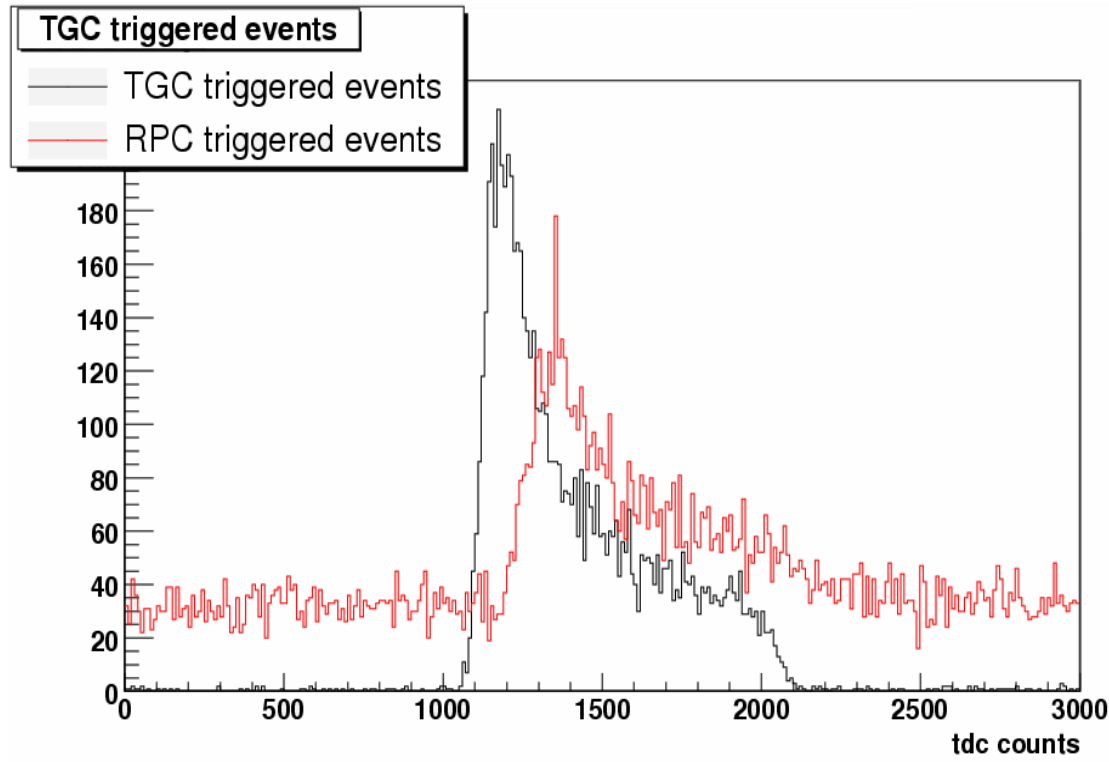
CAM - Content-Addressable Memory

Results (1)



Display of an event triggered by end-cap muon trigger with hits in muon precision chambers

Results (2)



- Events triggered by both, end-cap and barrel muon trigger, have hits in the muon precision chambers with characteristic muon TDC spectrum
- Trigger from barrel muon trigger reaches the muon precision chamber front-end electronics 130 ns earlier trigger than from end-cap muon trigger

Summary

- **Hardware is finished or about to be finished**
 - **New MIOCT: prototype tested, final production under way**
 - **New MIROD/CTP: prototype being built**
 - **LTPIM: prototype tested, final production under way**
- **Complete trigger and readout chain is being operated in the experiment using cosmic rays**
- **Effort is moving towards exploitation and operation**
 - **Work on online and offline software, e.g. monitoring**